

# IT INVESTMENT: THE UNEXPECTED EFFECTS ON ENTREPRENEURIAL SPAWNING

*Research-in-Progress*

**Qing Chen**

Department of Information Systems  
National University of Singapore  
13 Computing Drive, Singapore 117417  
[chenqing@comp.nus.edu.sg](mailto:chenqing@comp.nus.edu.sg)

**Ke-Wei Huang**

Department of Information Systems  
National University of Singapore  
13 Computing Drive, Singapore 117417  
[huangkw@comp.nus.edu.sg](mailto:huangkw@comp.nus.edu.sg)

**Cheng Suang Heng**

Department of Information Systems  
National University of Singapore  
13 Computing Drive, Singapore 117417  
[hengcs@comp.nus.edu.sg](mailto:hengcs@comp.nus.edu.sg)

## Abstract

*Despite the growing interests in entrepreneurial spawning, whereby employees leave an incumbent to become entrepreneurs, there is a lack of studies examining the impact of firm strategies on the process. However, IS literature has documented various influences of IT on firms. This study attempts to bridge these two streams of research by investigating the impact of IT investment (as a form of firm strategy) on entrepreneurial spawning. Drawing upon the IT-agility theoretical lens, we propose that IT investment may impede firms' entrepreneurial spawning. In addition, firms with higher IT investment are less adversely affected by spawns. We devise thorough empirical strategies to analyze Fortune 500 manufacturing firms from 1990 to 2006. Our study potentially contributes to the current research in entrepreneurship and business value of IT, and sheds novel insights on the retention of talents, exploitation of internal innovations and deterrence of potential competition.*

**Keywords:** Business value of IS/value of IS, IT investment, Strategic value of IT/IS, Econometric analyses

## Introduction

Entrepreneurial spawning, the process whereby one or more employees leave an incumbent to create a new venture (Gompers et al. 2005; Habib et al. 2013), is prominent in manufacturing industries such as disk drives (Franco and Filson 2006), semiconductors (Gompers et al. 2005), lasers (Klepper and Sleeper 2005), and medical devices (Chatterji 2009). According to Sørensen and Fassiotto (2011), over 90% entrepreneurs work for incumbents before launching their ventures. Entrepreneurial ventures can benefit the economy by intensifying technological innovation and reinventing business models (Carroll and Hannan 2000; Schumpeter 1934). However, from an incumbent's perspective, the outflow of high-quality employees not only constitutes a loss of talents, but also poses potential market rivalries that might jeopardize the source firm's performance (Campbell et al. 2012). Therefore, a thorough understanding of entrepreneurial spawning is of paramount importance to both policy makers and firm managers.

The purpose of this study is to shed light on the potential relationship between one form of firm strategies and entrepreneurial spawning, which is scant in existing literature (Andersson et al. 2012). Specifically, we focus on firm-level information technology (IT) investment due to the following two motivations.

First, existing research in entrepreneurship and IS seems to generate two competing hypotheses towards IT's impact on entrepreneurial spawning. On one hand, IT investment reduces firm size by automating processes and decreasing coordination costs (Brynjolfsson et al. 1994; Im et al. 2013). The firm size, at times, can be dramatically reduced. It has also been documented that small firms spawn more entrepreneurs because of higher chances to learn diverse skills and more exposure to external environments (Elfenbein et al. 2010). Thus, IT investment is expected to have a positive effect on entrepreneurial spawning. On the other hand, IT investment enables firms to proactively anticipate entrepreneurial opportunities (Chakravarty et al. 2013), facilitates internal communication (Argyres 1999), and accelerates innovation and commercialization (Joshi et al. 2010; Kleis et al. 2012). Thus, IT investment improves firms' agility in developing and capitalizing on germinated ideas, which in turn leaves fewer opportunities for employees to participate in entrepreneurship (Agarwal et al. 2004; Gompers et al. 2005). Hence, IT investment is expected to have a negative effect on entrepreneurial spawning.

Second, extant research predominantly examines the unidirectional influences from an incumbent to spawns, such as knowledge inheritance (Agarwal et al. 2004; Franco and Filson 2006) or performance transmission (Chatterji 2009), but neglects the potential reverse influence from spawns on source firm's performance, such as talent loss and market competition (Campbell et al. 2012). Aforementioned, IT has demonstrated considerable influences on firms' structures and capabilities, especially enabling firms' flexibility in face of environmental changes or new opportunities (Lu and Ramamurthy 2011; Sambamurthy et al. 2003). Hence, it is worth exploring whether these documented IT benefits may moderate the reverse impact from employees' entrepreneurship.

In essence, our research questions are:

- (1) *Whether firm-level IT investment encourages (or impedes) entrepreneurial spawning?*
- (2) *How does IT investment influence the adverse impact of entrepreneurial spawning on source firms' performances?*

As we shall subsequently detail, a close theoretical examination on both the "IT-firm size view" and "IT-agility view" helps us arrive at our eventual hypothesis of IT investment restraining (rather than encouraging) existing firms' entrepreneurial spawning, by increasing the efficiency in evaluating, commercializing and incorporating employees' innovations. We further hypothesize that IT investment may weaken the adverse impacts from spawns on source firms' performances by improving firms' capability in appropriating the value of relevant and superior innovations. Empirically, we propose to test our hypotheses by analyzing the Fortune 500 U.S. manufacturing firms from 1990 to 2006. Particularly, we adopt a newly developed measure for firm-level IT investment (Tambe and Hitt 2012; Tambe and Hitt 2014) and identify entrepreneurial spawning from a large online resume database. In terms of identification strategy, we both adopt a structural modeling technique (Levinsohn and Petrin 2003; Olley and Pakes 1996) and construct instrumental variables to alleviate any potential endogeneity concerns for IT investment. We also devise complementary analyses and falsification tests to corroborate our hypotheses.

## **Potential theoretical contributions**

Our study contributes in several important ways. First, we advance theoretical understanding by responding to Sørensen and Fassiotto (2011)'s recent call to examine the interface between incumbents and entrepreneurial ventures. Specifically, we surpass past works that primarily focus on firm properties (e.g., age and size) by underscoring a strategic prescription, which top management can enact upon and be proactive in (i.e., IT investment) so as to better guard against entrepreneurial spawning. Second, we refine and enrich the well-documented "small firm effect" in the entrepreneurship literature (Elfenbein et al. 2010; Gompers et al. 2005). Specifically, we challenge the simplistic understanding of "small firm effect" (i.e., merely equating it to firm size) to accentuate the importance of unraveling the mechanisms to which firm size alters (i.e., IT-induced structure change). Third, our study is among the pioneering studies to unravel the value of IT in efficiently allocating human resources between incumbents and new ventures. Since IT helps firms optimally adjust their product portfolio, employees who innovate are tempted to stay put within incumbents to bear fruition to their ideas, while those exploring less relevant innovations would leave for entrepreneurship. Fourth, our findings may trigger a critical reevaluation of the contribution of IT on innovation productivity. If IT indeed decreases entrepreneurial spawning as we have conjectured, previous estimation of IT contribution on innovation (Kleis et al. 2012) might be overestimated. In prior studies, due to the "overlooked" reduction in entrepreneurial spawning by IT, more innovations ended up retained in incumbents and were erroneously attributed to IT productivity. Fifth, our analyses provide novel and vital empirical evidences in support of "IT agility" studies (Chakravarty et al. 2013; Lu and Ramamurthy 2011). While current works predominantly rely on subjective measurements by executives to validate the effects of IT, our analyses that adopt objective measures of employee entrepreneurship activities are a major step forward corroborating entrepreneurial agility and adjustment agility. With the findings, our study hopes to chart practical implications for managers regarding the retention of talents, exploitation of internal innovations and deterrence of potential competition.

## **Literature Review**

### ***Entrepreneurial spawning***

Entrepreneurship is often characterized by the dispositional view or contextual view. Researchers advocating the dispositional view claim that an individual's entrepreneurial activity is largely driven by stable personal traits. For example, several studies have revealed that risk tolerant individuals are more likely to become entrepreneurs (Ekelund et al. 2005; Hvide and Panos 2014). Concurring, Holm et al. (2013) demonstrate that entrepreneurs are more willing to accept strategic uncertainty. Besides, Dunn and Holtz-Eakin (2000) investigate the inter-generation link and find inherited human capital exerts a strong influence on next-generations' entrepreneurial decision. When the five-factor model of personality is examined (Zhao and Seibert 2006), entrepreneurs scored higher on Conscientiousness and Openness but lower on Neuroticism and Agreeableness.

On the other hand, proponents of the contextual view advocate that a person's position in his/her social structure may encourage or retard entrepreneurial activity. For example, some studies reveal that those who are from self-employed families are more likely to become entrepreneurs because of inherited financial and social capital (Halaby 2003; Sørensen 2007b). Other studies also present the significant contextual influences from regional culture (Sorenson and Audia 2000), work environment (Dobrev and Barnett 2005) and social networks (Lerner and Malmendier 2013).

Recently, a growing stream of research seeks to understand how incumbents' characteristics may shape entrepreneurial activities. For example, using analytical models, Habib et al. (2013) predict that older firms spawn less and that firms with more valuable resources (such as know-how, patents) spawn more. Klepper (2007) underscores the importance of "strategic disagreement" in inducing entrepreneurial spawning.<sup>1</sup> Furthermore, Cassiman and Ueda (2006) consider the fit between existing business and new innovations to suggest that firm's optimal rejection of new innovations induce entrepreneurial spawning. Most empirical studies reveal a negative correlation between firm age (or size) with employees'

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<sup>1</sup> "Strategic disagreement" refers to divergent views or tensions between employees and top managers about firm strategy such as product development or merger and acquisition.

entrepreneurial spawning (Dobrev and Barnett 2005; Gompers et al. 2005; Sørensen 2007a). Concurring, Elfenbein et al. (2010) also empirically validate the “small firm effect” to arrive at explanations such as preference sorting, ability sorting, less opportunity cost, more diverse skills, and higher exposure for external opportunities. Other works also suggest significantly positive influences from unexploited technological know-how (Franco and Filson 2006; Ganco 2013) and specific firm location (e.g., Silicon Valley) on entrepreneurial spawning (Gompers et al. 2005). Apart from the above findings, the current literature is still nascent and Sørensen and Fassiottto (2011) suggest more research to explore the interface between existing firms and new ventures.

### ***Business value of IT***

Prior research on business value of IT has established some links between firm-level IT investments and various outcomes. First, IT has demonstrated its positive influences on firm performances. For example, IT contributes to firms’ productivity by streamlining business processes and optimizing efficiency (Brynjolfsson and Hitt 1996; Tambe and Hitt 2012). IT also has a positive complementary effect with R&D investments to increase intangible outputs production (Kleis et al. 2012). Moreover, IT positively impacts firm value (Bharadwaj et al. 1999), stock prices (Dos Santos et al. 1993) and profitability (Mithas et al. 2012).

Second, IT substantially affects firm structure. For example, IT is found to decrease organizational bureaucracy, flatten and decentralize organization structures (Argyres 1999; Hitt and Brynjolfsson 1997). Brynjolfsson et al. (1994) and Im et al. (2013) also find that IT decreases firm size despite their different units of analyses. In terms of firm scope, Hitt (1999) finds that IT decreases vertical integration while weakly increases diversification. Instead of investigating the direct impact of IT, Ray et al. (2013) suggest that IT moderates the relationship between existing assets and firm boundary (e.g., vertical integration, diversification).

Third, IT enables firms’ capabilities. For example, Joshi et al. (2010) suggest that IT equip firms with knowledge capabilities and has a positive effect on innovations and new product introductions. Mithas et al. (2011) assert that IT plays a critical role in developing other firm capabilities such as better customer management, process management, and performance management.

Recently, one stream of studies becomes increasingly prominent in investigating the relationship between IT investment and firms’ agility (i.e., a firm’s capability to cope with rapid, relentless, and uncertain changes and thrive in a competitive environment of continually and unpredictably changing opportunities) (Lu and Ramamurthy 2011). In one viewpoint, IT impedes firms’ agility since business are constrained by legacy IT systems, rigid IT architectures, or complex nests of technology artifacts (Newell et al. 2007; Tallon 2008). In another viewpoint, it is suggested that IT may enhance firms’ agility, through facilitating communication, speeding up decision making, and responding quickly to external conditions (Lucas Jr and Olson 1994; Nazir and Pinsonneault 2012; Roberts and Grover 2012; Sambamurthy et al. 2003; Tallon and Pinsonneault 2011; Weill et al. 2002). Specifically, by refining the conceptualization and measurement, Lu and Ramamurthy (2011) and Chakravarty et al. (2013) provide empirical evidences to support that IT enables organizational agility in market capitalizing and operational adjustment. Hence, in this study we choose to reflect the viewpoint of “IT facilitates agility” from a unique perspective of employees’ entrepreneurship.

### ***Hypotheses Development***

To unravel how IT investment influences entrepreneurial spawning, we examine the underlying logic in depth to reject the “IT-firm size” arguments, but support the “IT-agility” arguments by proposing three mechanisms through which IT may discourage entrepreneurial spawning.

Based on the “IT-firm size” arguments, small firms usually spawn more ventures (Dobrev and Barnett 2005; Gompers et al. 2005; Sørensen 2007a) and IT investment seems to increase entrepreneurial spawning by reducing firm sizes (Brynjolfsson et al. 1994; Im et al. 2013). Prior studies have offered several explanations as to why employees from smaller firms may have higher probability to emerge entrepreneurs, apart from preference and ability sorting (Dobrev and Barnett 2005; Elfenbein et al. 2010). First, it is easier for employees in small firms to develop diverse skills necessary for successful entrepreneurship (Lazear 2004), as compared to their counterparts in role-specific large firms. Second, employees working in smaller firms may have more access to external information and networks of

entrepreneurial nature so as to recognize entrepreneurial opportunities (Gompers et al. 2005). Third, employees in smaller firms may face less opportunity costs in exiting given that a clear career track is often not as well charted as in established firms (Elfenbein et al. 2010). Despite these three conjectures, we argue that firms' IT investment decreases firm sizes mainly through labor substitution and coordination cost reduction (Im et al. 2013), and it hardly intensifies any of the above three effects. On the contrary, IT-based productivity tools reinforce employees' role specialty and differentiation, rather than imparting them diverse knowledge. Additionally, there is a subtle but important conceptual difference between "small firm" and "reducing firm size". Although IT investment might indeed reduce firms' size, it hardly switches "medium-to-large-sized" firms to "small-sized" firms: those medium-to-large-sized firms will readjust and optimize their firm size but often, remain as medium-to-large-sized firms. Hence, we argue that IT investment may not trigger entrepreneurial spawning through reducing firm sizes.

Instead, "IT-agility view" may elucidate three mechanisms through which IT negatively affects entrepreneurial spawning.

First, IT enables firms' agility in continually sensing opportunities for competitive actions (Sambamurthy et al. 2003), which facilitates better evaluation process for internal entrepreneurial opportunities. Without IT, it is difficult to analyze "soft" information to assess the potential of an entrepreneurial idea (Stein 2002). Without proper evaluation of these innovative ideas (Gompers et al. 2005), employees are often tempted to leave the incumbent so as to start their own firms to materialize these ideas into new products (Garvin 1983). With IT, an integrated platform to standardize communication and integrate data processes between different departments is provided (Lu and Ramamurthy 2011). IT-based communication technology (e.g., video conference and e-community) facilitates information exchange among different hierarchical layers (Argyres 1999) whereas information management technology (e.g., databases and knowledge management systems) enables data codification, knowledge extraction and support decision making in a timely and accurate manner. Overall, the decreased information processing costs facilitate better information flow within firms. Thus, IT investment helps top management better obtain and synthesize necessary information from multiple sources efficiently and better evaluate novel ideas from employees. In essence, IT may reduce entrepreneurial spawning by making firms agile at the stage of opportunity recognition.

Second, IT develops firms' operational agility in accomplishing speed, accuracy, and cost economy in business process, which accelerates the implementation and commercialization of new ideas. Apart from the lack of opportunity evaluation, another major reason driving entrepreneurial spawning is firms' inertia in applying innovations (Gompers et al. 2005). According to the "Xerox view" (Gompers et al. 2005), Xerox has invented many advanced technologies for computers, but has lagged behind in transforming these inventions to successful products. As a result, employees leave to exploit market values of these inventions and start new ventures, including Adobe Systems and 3Com, reiterating the importance of inertia in applying innovations. Aforementioned, IT systems effectively integrate various information among market needs, technical expertise and manufacturing design, thereby enhancing firms' knowledge capability and increases the conversion from innovations to new products and services (Joshi et al. 2010). Additionally, by benefiting from personal productivity tools and enterprise systems (e.g., ERP or SCM), IT can improve firms' productivity (Brynjolfsson and Hitt 1996; Kleis et al. 2012; Tambe and Hitt 2012) and enable them to quickly test new products' market reactions for subsequent decisions. Again, IT may reduce entrepreneurial spawning by delivering firms' agility at the stage of idea realization.

Third, IT enhances firms' agility in marshaling necessary knowledge and assets (Sambamurthy et al. 2003), which confers firms with better flexibility to embrace newly developed products. This helps overcome the commonly cited obstacle of employers being reluctant to accept new products because it tends to upset the established ways in "organizing" businesses (Gompers et al. 2005; Klepper 2007; Klepper and Sleeper 2005). For example, Steve Wozniak, the cofounder of Apple, had once presented the prototype of Apple I to managers when he was employed by Hewlett-Packard. Although managers in Hewlett-Packard foresaw the value of this novel design, they eventually rejected it because they opined that it did not fit well with the existing HP computers (Isaacson 2011). Notably, IT enables firms' dynamic capability in sensing and seizing market opportunities proactively. For example, IT-based decision support systems or statistical tools might assist in analyzing and predicting how introduced new products might affect the firm and its competition, thus simulating strategic scenarios for adjustment decisions

(Wixom and Watson 2001). Moreover, IT also allows a firm to modify its strategy positioning and re-organize new business approaches to achieve early advantages (Sambamurthy et al. 2003). With IT-based communication and coordination tools, firms can increase knowledge reach, such that stakeholders can better understand and participate to improve business processes. In addition, firm-wide applications, databases, and systems can quickly implement extensive and radical process changes. Overall, IT can reduce entrepreneurial spawning by enhancing firms' agility at the stage of product incorporation.

In summary, IT investment prevents entrepreneurial spawning with more acute opportunity recognition, idea realization, and product incorporation. It confers firms with a better agility to seize and bear fruit on internally germinated ideas. Therefore, we propose our first hypothesis.

**H1:** IT investment has a negative impact on the rate of entrepreneurial spawning.

We also examine how IT investment influences the relationship between the spawns and source firms. Prior studies have informed that employees' entrepreneurship exert a large adverse impact on source firm performance, due to talent loss and market competition (Campbell et al. 2012). However, based on the IT-agility view, firms benefit from IT in better assessing opportunity, detecting market dynamics, and configuring existing business line with newly developed products. Hence, we expect that those ventures that are spawned from source firms with higher IT investment will suffer from a poorer chance to operate in a similar market with competitive products. In other words, competitive technologies or products, which can potentially invade market shares and threaten firms' performances, are more likely to be retained by firms with higher IT investment. Hence, we propose our second hypothesis with IT investment as a moderator.

**H2:** Firms with higher IT investment are less negatively affected by entrepreneurial spawning.

## Data and Measures

### Sample

Consistent with studies examining business value of IT (Brynjolfsson and Hitt 1996; Im et al. 2013; Kleis et al. 2012), we investigate the Fortune 500 manufacturing firms from 1990 to 2006 and assemble our dataset from several sources.<sup>2</sup> First, we collect employee micro-data from a leading professional social networking site, which contains more than 200 million individuals' resumes. In each resume, the employee reports information including employer name, job title, and the dates of employment for every position. This large sample of career histories enable us to identify the time an entrepreneur leaves an existing firm (if so) to start the new venture. We then aggregate these entrepreneurial activities to a firm-year level from an existing firm's view. Next, we collect patent data from NBER database. We also obtain publicly available financial data (e.g., revenue, number of employees, R&D expense) of our sample from COMPUSTAT/CRSP merged database. For further analyses (to be explained later), we also extract the texts in sample firms' 10-K annual reports.

### Variables

Dependent variable: In H1, the dependent variable is the rate of entrepreneurial spawning (*Rate\_ES*), which is the logarithm of number of new ventures spawned from an existing firm in a specific year (plus one to avoid dropping non-spawning cases) (Gompers et al. 2005).<sup>3</sup> For robustness checks, we also operationalize *Rate\_ES* as the logarithm of number of employees leaving for entrepreneurship (plus one). In Hypothesis 2, the dependent variable is firm value of existing firms and is measured by *Tobin's Q*. Indeed, *Tobin's Q* measures a firm's market value relative to its book value and we follow Chung and Pruitt (1994)'s method to calculate it.<sup>4</sup> The literature has validated the advantage of *Tobin's Q* in embodying not only the profitability from market competition, but also firms' intangible assets such as human resources and technological advantages (Bharadwaj et al. 1999). Hence, *Tobin's Q* is appropriate to test our hypothesis.

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<sup>2</sup> We end our sample period in 2006 because of the restriction of NBER patent database.

<sup>3</sup> We check the sample to rule out the cases of corporate spinouts.

<sup>4</sup>  $Tobin's Q = (MVE + PS + DEBT) / AT$ , MVE = closing price end in the fiscal year  $\times$  number of common shares outstanding, PS = liquidation value of outstanding preferred stock, DEBT = current liabilities - current assets + book value of inventories + long-term debt, AT = the book value of total assets.

Independent variable: Our focal variable is IT investment (*IT\_investment*), which is an independent variable in H1 and a moderator in H2. Adopting the newly developed measurement (Tambe and Hitt 2012; Tambe and Hitt 2014), we first obtain the firm-level IT employees based on the reported job titles from the resume database. We then calculate the firm-level *IT\_investment* as the percentage of IT employees counts over the total headcounts for a firm in a specific year. The labor-based IT-investment measure has several advantages, as compared to traditional capital-based measure (Brynjolfsson and Hitt 1996; Brynjolfsson and Hitt 2003). For example, labor expenditure accounts for more than double that for capital in IT budget.<sup>5</sup> Besides, IT employees are more related to firms' internal IT intangible asset such as application development, system implementation, and employee training. To corroborate its use, Tambe and Hitt (2012) empirically validate this measure by illustrating the high correlation (>0.6) with traditional IT measures and achieving consistent findings when replicating previous analyses.

Control variables: To mitigate plausible alternative explanations, we also control for other factors that might influence our dependent variables based on previous literature (Elfenbein et al. 2010; Gompers et al. 2005; Sørensen 2007a). The variable *firm\_size* is the number of employees, which measures firms' resources. The variable *Growth\_Rate* captures firms' growth prospect and is measured as the rate of growth of a firm's yearly revenue with respect to the previous year. The variable *Operating\_Margin* accounts for the firms' operating profitability. *R&D\_intensity* measures the extent to which firms invest in innovation activities and is calculated as the R&D expenditure per employee (Mithas et al. 2012). *Patent\_quality* and *Patent\_originality* are constructed using NBER patent database to measure firms' technological advantages (Gompers et al. 2005). We construct Herfindahl Hirschman index (*HHI*) to capture industry concentration (Chang and Gurbaxani 2012). We also include year dummies to control for time-specific effects.

## Empirical Strategy

Our formal panel model specifications are provided in equation (1) and (2), in which *i* denotes an existing firm and *t* indicates focal year;  $\alpha_i$  represents firm-specific effect and  $e_{it}$  is the residual. The independent variables are lagged one year to reveal causality. Equation (1) is used to test H1 and we expect coefficient  $\beta_1$  to be negative and significant. Equation (2) is used to test H2 and we expect coefficient  $\beta_3$  to be positive and significant.

$$Rate\_ES_{it+1} = \beta_0 + \alpha_i + \beta_1 IT\_investment_{it} + Controls_{it} + \sum Year\_duumy + e_{it}, \quad (1)$$

$$TobinQ_{it+1} = \beta_0 + \alpha_i + \beta_1 Rate\_ES_{it} + \beta_2 IT\_investment_{it} + \beta_3 Rate\_ES_{it} * IT\_investment_{it} + Controls_{it} + \sum Year\_duumy + e_{it}. \quad (2)$$

Although our main analysis uses panel models to deal with the unobserved time-invariant firm heterogeneity, there may still be some concerns over potential endogeneity issues. First, prior studies have argued that firms may optimize their investment inputs with respect to the production efficiency, which is observable to managers but unobservable to researchers (Olley and Pakes 1996). Second, firms' bureaucracy or workplace cultures might influence IT investments, and correlate with entrepreneurial spawning. Thus, OLS estimation of *IT\_investment* might be biased due to these omitted variables (e.g., unobserved productivity, firm culture). We adopt two approaches to address the endogeneity concern. First, we employ a structural modeling approach, which is developed in the productivity estimation framework (Levinsohn and Petrin 2003; Olley and Pakes 1996). Essentially, this method estimates the unobserved productivity shocks with intermediate inputs as proxies. In addition, for the endogenous variable *IT\_investment<sub>it</sub>*, we develop two instrumental variables: *NumCollege<sub>i</sub>\*IT\_Profitability<sub>t-4</sub>* and *NumCollege<sub>i</sub>\*IT\_Growth<sub>t-4</sub>*. Specifically, *NumCollege<sub>i</sub>* is the number of colleges and universities in the state where firm *i*'s headquarter locates. *IT\_Profitability<sub>t-4</sub>* and *IT\_Growth<sub>t-4</sub>* are the average profitability and sale growth of IT industry four years ago. Our instruments are reasonable in that if the performances of IT industry are better in year *t-4* (in terms of profitability and growth prospect), more freshmen would choose IT-related majors such as computer science or information systems. Then, after four years when

<sup>5</sup> <http://www.informationweek.com/news/management/showArticle.jhtml?articleID=192600107>

they graduate, there will be more IT labor supply in the market. This effect is stronger when more colleges are near firms' locations. The increased labor supply subsequently facilitates firms' IT investment. Therefore, our instruments are positively correlated with firms' IT investment. However, employee entrepreneurial activities in manufacturing firms are not likely to be directly correlated with the market supply of IT skills. Thus, our instruments are not directly correlated with the residuals of our regressions.

We also propose several further analyses to corroborate our hypotheses. First, we seek to verify our theoretical mechanisms empirically. According to our IT-agility arguments, IT investment may enhance firms' capability in configuring products portfolio in the face of emerging innovations. Hence, we expect a positive relationship between *IT\_investment* and *Product\_adjust\_efficiency*, which is defined as the ratio between *Product\_portfolio\_adjustment* and number of recently assigned patents. To measure the *Product\_portfolio\_adjustment*, we employ a text mining algorithm to analyze the "product description section" of firms' 10-K annual reports, which usually appears in the first segment (Hoberg and Phillips 2010a; Hoberg and Phillips 2010b). Particularly, for a specific firm  $i$  in year  $t$ , we calculate the dissimilarity of product description texts between year  $t$  and  $t-1$  to measure *Product\_portfolio\_adjustment<sub>it</sub>*.<sup>6</sup>

Furthermore, we seek to dismiss plausible alternative explanations with falsification tests and theoretical evidences. For example, some may rationalize that the hypothesized negative correlation between IT investment and entrepreneurial spawning is due to a firm investing less in IT, and lagging behind in deploying advanced technologies, resulting in it becoming less attractive and triggering exit of employees to embark on entrepreneurship. We examine this possibility by investigating the relationship between IT investment and employees' turnover rate. To falsify the above explanation, we expect to observe that IT investment has quantitatively different effects on employees' turnover rate and entrepreneurial spawning. As another example, someone might speculate that our estimation of the IT effect could be attenuated by the labor substitution effect of IT (Im et al. 2013). With increasing use of IT, many employees' jobs are taken over by automated processes. Those laid-off employees may choose to become entrepreneurs and hence, contradict our hypotheses. Nevertheless, previous studies have documented that (i) IT mainly affect employees with routine and clerical works (Brynjolfsson and Hitt 2003; Orlikowski and Robey 1991) while (ii) employees who leave to start new ventures are typically of high quality workforce (Campbell et al. 2012; Carnahan et al. 2012) and possess diverse skills (Sørensen and Fassiotto 2011). Therefore, the substitution effect would not undermine our expected findings.

In the end, we conduct multi-group analysis to check whether our results are robust across different industries. We also investigate whether the moderating effect (H2) is more pronounced for ventures that are spawned in the same industry as source firms than ventures that are spawned in the different industry from source firms.

## Conclusion and Future Plan

The objective of this paper is to investigate how firms' IT investment may affect entrepreneurial spawning. Adopting the IT-agility theoretical lens, we hypothesize that IT may negatively affect employees' entrepreneurial activities and reduce the adverse impacts from spawns on source firms. We also specify empirical strategies to construct measurements, test hypotheses, address endogeneity concerns, demonstrate complementary evidences and cope with alternative explanations. As this is still a research-in-progress paper, we hope to explore extensions for further implementation. For example, we may attest our findings using alternative IT measures. Besides the current labor-based IT investment, we can also operationalize firm-level IT capability using *InformationWeek 500* listings (Chae et al. 2014; Santhanam and Hartono 2003). Specifically, we identify firms in *InformationWeek 500* listings as leaders in IT capability. For each IT capability leader, we intend to find control firms in the same industry with comparable revenues. We compare entrepreneurial spawning between the above two groups to test our hypotheses.

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<sup>6</sup> We describe each product description text using a vector of TF-IDF values, and calculate the cosine of two vectors to measure the dissimilarity of two texts.



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